Integrating Weather Exploitation into Airpower and Space Power Doctrine

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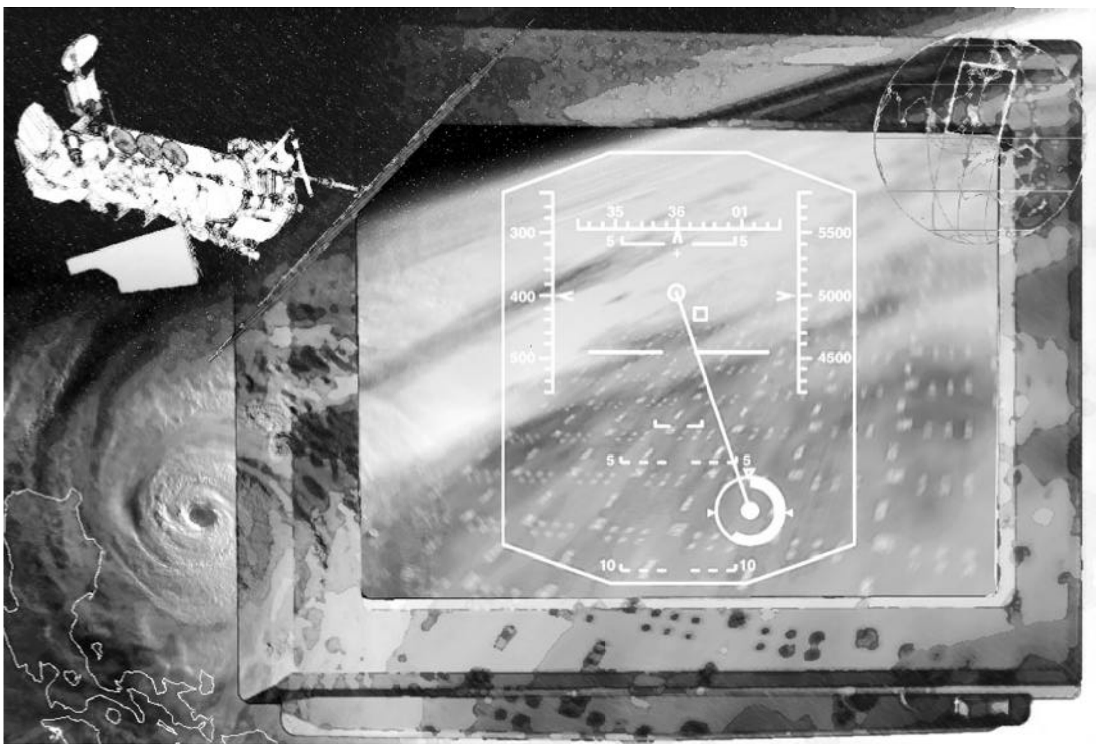

The theater commander nervously pondered his options. The success of this combined operation would depend heavily upon the weather. He needed accurate predictions to execute several key parts of the operation, such as cloud cover and low-level winds for airborne operations and favorable moon, tide, and sea states for the amphibious portion. Deception played a significant part of this mission as well; his forces needed to conduct diversionary bombing runs over another portion of the littoral region to deceive the enemy into thinking this would be the main

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area of invasion. The weather in-theater had been marginal to unfavorable for the last three days. The enemy, an industrialized nation, had a capable weather service, so if favorable weather were predicted by the friendly side, chances were the enemy would know this too. One big advantage the friendly forces had was the availability of additional weather observations over the ocean and land areas to the west and north of the theater of operations. They could possibly apply this "information superiority" by using the additional data to make a more accurate forecast than that of the enemy. Finally, the forecasters predicted a period of slightly improving, although still operationally marginal, conditions. Weighing the weather factors against the operational objectives and knowing that the next favorable opportunity for this combined operation wouldn't occur for another two weeks, the theater commander made the decision to launch.

THIS EXAMPLE of weather exploitation is neither hypothetical nor futuristic—it occurred over 50 years ago. The theater commander was Gen Dwight D. Eisenhower, and the combined operation was Overlord—the D-day invasion of Europe in World War II. Exploiting the natural environment in military operations is nothing new. Sun Tzu, the Chinese general, said as much nearly twenty-five hundred years ago: "Know yourself, know your enemy; your victory will never be endangered. Know the ground, know the weather; your victory will then be total."[1]

So what is new? For starters, the explosion in both information and technology is beginning to affect the way we think about warfare, especially in air and space. Although these technological changes are daunting enough, we should consider the simultaneous changes in the political and military "landscape" within the last five years (e.g., the change from the monolithic Soviet threat to multipolar, ill-defined threats; rethinking traditional service roles and missions; and the emergence of military operations other than war [MOOTW] as a rapidly growing mission area). Unprecedented changes in technology and the world order have brought new questions about time-honored principles of war fighting that have been developed and battle tested over so many years. Has the United States become so technologically sophisticated that it is "forgetting" some commonsense principles of warfare? Will the increasing reliance upon precision weaponry combine with restrictive rules of engagement (ROE) and a force strategy based in the continental United States (CONUS) to make us more vulnerable to a potential adversary instead of less vulnerable? According to a RAND study on the future of warfare,

> we expect opposition attacks on US air forces because of the importance of these forces. An opponent attempting to overcome US air power might do so by a campaign that focuses on limiting the number of US aircraft in a theater area, reducing the number of sorties that the aircraft in theater can fly, and/or limiting the effectiveness of sorties against targets. In turn, the number of sorties can be limited by damaging airfields, damaging national logistics (for example, destroying POL [petroleum, oil, and lubricants] distribution and refining capabilities), *or timing a conflict to correspond (to the extent controllable) with bad weather*. (Emphasis added)[2]

This article outlines a strategy for developing new and innovative ways to exploit terrestrial and space weather in battle—a "weather exploitation doctrine." A key part of the strategy requires building sophisticated weather-effects models and simulations and employing them to enhance the ability of airpower and space power to exploit the environment

at all mission levels, from individual engagements to theater and campaign planning and execution. The article briefly discusses how weather exploitation complements the four-dimensionality of airpower and space power by adding another "dimension" (information) to the battle space. The discussion continues by outlining five policy areas that are converging to make the employment of airpower and space power more challenging—and more vulnerable to the natural environment. The article then describes weather services in their role as an integral part of command and control (C^2), followed by a formal definition of weather exploitation. Finally, the article addresses the motivation for using modeling and simulation (M&S) as the means for developing a weather exploitation capability and integrating it into airpower and space power doctrine.

Background and Motivation

The USAF mission is "to defend the United States through control and exploitation of air and space." Air Force Doctrine Document (AFDD) 1 describes the advantages of the air and space media in terms of three-dimensional maneuver.[3] No one would argue against the ability of airpower and space power to capitalize upon the atmospheric and space media (e.g., space power's ability to "see" the entire battlefield or airpower's ability to penetrate deeply into the enemy's interior to mass overwhelming firepower within a very short time).

This article proposes that we apply the medium of information—in the form of "weather intelligence"—to develop better ways for airpower and space power to exploit the vertical and time dimensions in combat. Although air and space do not have solid obstacles such as mountains and forests, they do have "physical" obstacles, such as clouds, fog, thunderstorms, and ionospheric storms. Land and sea forces have learned to take advantage of their environments by turning their "obstacles" into exploitable allies (e.g., designing forces to operate in "close terrain" and building submarines to exploit the acoustic environment of the deep oceans). The time has come for airpower and space power to fully exploit information about atmospheric and space weather obstacles in the same ways that land and sea forces do in their environments.[4] One can illustrate the reasons for looking at such a strategy by examining several recent policy trends that are putting an increasing strain on the ability of airpower and space power to accomplish their missions.

If the United States is to rely increasingly on space-based assets for force enhancement and information dominance, it must remain aware of its own vulnerabilities to the space environment, as well as those of its adversary.

Shrinking Force Structure and a CONUS-Based Force

Commanders are less able to tolerate "weather aborts" and diversions from primary and secondary targets in a resource-constrained environment. A key capability of airpower in a CONUS-based force structure is its capacity to project power quickly and decisively into a theater. Airpower projection can range from a single surgical-bombing mission to "send a message" and a multiple-sortie raid against a number of targets, to a large-scale deployment of personnel and equipment during a developing major regional contingency (MRC). Given a lack of forward basing, weather becomes a greater factor in logistics and long-duration missions with multiple aerial refueling. Today, as much as ever, adverse weather could spell disaster for a 20-hour round-trip mission from CONUS to some overseas location; extended periods of

adverse weather could seriously delay critical deployment of heavy equipment and troops into theater.

Increasing Reliance on Precision-Guided Munitions

The success of PGMs in Operation Desert Storm was both a blessing and a curse. In the next combat operation, the expectation for PGM accuracy will be at least as great as that in Desert Storm, if not greater.[5] What if the next contingency were in a much more complex climatic and topographic region, such as Bosnia or Korea? Because of the great cost of PGMs (over $100,000 per copy), we cannot afford to waste these assets due to weather-related reasons; naval aviation has an even more serious problem in that aircraft *must* expend ordnance before returning to the carrier. Given the enormous costs of PGMs and the appearance of "brilliant" weapons on the technology horizon, it is more important than ever for environmental-technology developments to keep up with airframe-technology developments such as stealth.[6]

Space-Based Assets and the Solar-Disturbance Maximum

Desert Storm was truly the first "space war." Over 90 percent of in-theater, out-of-theater, and into-theater communications were borne by military and commercial satellites.[7] In the next contingency, we will rely even more heavily on satellites for intelligence, communications, navigation, and battle-space monitoring. Threats to these systems come not only from terrestrial sources (e.g., sabotage to receiving stations and launch facilities and damage from severe weather) but also from the space environment itself. For example, geomagnetic storms can increase satellite drag, causing orbital changes that affect sensor performance, satellite control, and space-object tracking.[8] If the United States is to rely increasingly on space-based assets for force enhancement and information dominance, it must remain aware of its own vulnerabilities to the space environment, as well as those of its adversary. This is especially true as we approach the next sunspot-maximum period, projected to occur between 1998 and 2002. Any advantage in the information war gained from superior access to space could quickly evaporate if we lose satellite access due to damage from electrical charging, or if we experience degradation of communications by upper-atmospheric disturbances.

Evolving Rules of Engagement

Two recent policy trends regarding ROEs will make the employment of airpower more complex: (1) minimizing friendly casualties and (2) minimizing collateral damage. Although the United States has always been sensitive to the problem of friendly casualties, recent trends toward reducing fratricide and unnecessary enemy casualties (disable versus destroy) will also tax airpower's ability to deliver weapons in more accurate and effective ways. Sensitivity over excess collateral damage will require that air strikes be planned more precisely and executed with a much higher degree of accuracy than ever before. Both of these trends and restrictions, when combined with adverse weather conditions, complicate airpower's ability to accomplish the mission. A case in point is Operation Deliberate Force (NATO air strikes against Serb military targets in the fall of 1995), in which the "zero tolerance" policy on collateral damage combined with adverse weather to limit airpower's ability to strike targets effectively.[9] In this case, it was not the weather alone so much as the weather *combined with* restrictive ROEs that caused the problem.

Military Operations other than War

An increasingly visible proportion of the US military's operations tempo today is dictated by MOOTWs. In contrast to MRCs, for which much study and training have been done, MOOTWs frequently occur in climatically challenging areas, usually with no indigenous weather-observing network. These opera-

Table 1

Translation of Weather Analysis and Forecasting Products

WEATHER ANALYSIS/FORECAST	TAILORED WEATHER APPLICATION	OPERATOR DECISIONS
Cloud cover, visibility	Tactical decision aid	Target/weapon selection, battle damage assessment
Flight-hazard forecast (turbulence, icing)	Aerial-refueling forecast	Target route planning, air tasking order decisions
Ionospheric forecast	Maximum usable frequency Lowest usable frequency	Availability of HF support (communications)
Precipitation accumulation	Trafficability forecast	Ground-forces maneuver, river crossings

KNOW → APPLY → EXPLOIT →

tions are often short-notice, with a greater potential for weather to become a "single point of failure" due to the unpredictable nature of the missions themselves. To date, weather-service requirements in MOOTWs have been driven largely by ground forces, which need high-resolution, accurate weather data. The ever-present possibility of mission swing requires rapid updating of current conditions and forecasts in order to develop responses to a quickly changing operational environment.

Weather in Conventional Operations

It is useful to view the collection, analysis, and dissemination of weather information to the war fighter as an integral part of C^2. Four steps occur in this process (fig. 1).

Historically, the Department of Defense (DOD) has made nearly all of its science and technology (S&T) investments in the "data collection" and "weather analysis and forecasting" portions of the atmosphere and space environmental areas. For example, S&T funds spent on weather satellites and tactical observing systems contribute to our ability to collect data, and a considerable amount of funding has also been invested to improve weather analysis and forecasting. We should not downplay the importance of data collection, analysis, and forecasting in delivering quality environmental services to the operator; however, the weakest area in terms of de-

Figure 1. Collection, Analysis, and Dissemination of Weather Information (adapted from Lt Col H. L. Massie Jr., Col D. C. Pearson, Maj K. S. Smith, and R. Szymber, "Knowing the Weather" [paper presented at the Battlespace Atmospherics Conference, US Army Research Lab, White Sands, New Mexico, 1995])

velopment efforts has remained "tailored weather applications for operators." We believe that models and simulations incorporating realistic environmental effects will have the greatest potential impact to the operations community in these tailored applications and "operator decisions," although the latter is really the bottom line. In order to understand why, we can illustrate how a few military weather-analysis and forecasting products can be translated to weather-effects information—and ultimately to weather impacts on operations.

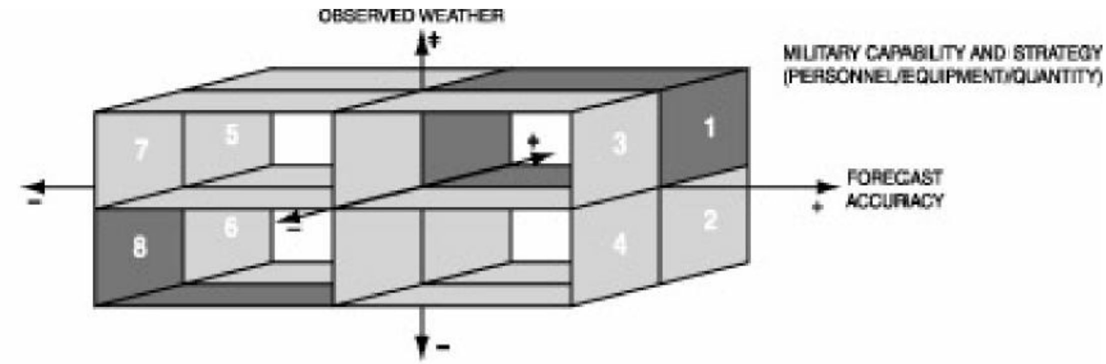
Weather analyses and forecasts are translated to mission-tailored weather application products (table 1). This service is usually provided by a highly trained staff weather officer or noncommissioned officer (NCO). Translation of the weather application product to an operator decision is the least understood link in the process. Suppose that a decision tool were available to help joint force component commanders (air, land, or sea) account for the effect of weather on their operations and for uncertainties in the weather prediction—or even help factor weather into the strategy. What if such a tool were available during campaign *planning* in addition to execution? It could be either a stand-alone capability or part of a comprehensive operational planning and execution system, allowing weather ser-vice to become more integrated into the information operations of the joint force commander's (JFC) team. With the advent of sophisticated, computer-based models and simulations, the technology is now available to develop such tools to aid the JFC's staff in its planning and execution duties, as well as to make these tools available for mission planning and rehearsal.

Weather Exploitation Defined

At this point, one might logically ask what weather exploitation is. Concisely put, weather exploitation is the deliberate use of knowledge about friendly and enemy operating capabilities under given natural environmental conditions *to set the terms of battle,* resulting in optimal performance of the friendly force and reduced effectiveness of the enemy force. Using this definition, one can examine and assess three aspects of weather exploitation.

The first, and most important, is the capability of the military force in terms of personnel (experience and training), equipment (quality and quantity), and doctrine (the correct way to employ the military force to accomplish the mission). Taken as a whole, a nation's military capability is largely independent of the natural environment. However, individual engagements, missions, or even campaigns can be significantly affected by the natural environment. This idea is embodied in the second aspect to be considered—the effect of *relevant*[10] observed weather on the military operation(s) (favorable, marginal, or unfavorable). This area requires the most improvement in terms of learning the vulnerabilities of both sides and incorporating that intelligence into air and space campaign strategy. The third aspect of exploitation is the accuracy of the prediction of relevant observed weather, which is particularly important in the planning phase, when forces/weapons mixes and strategy decisions such as target selection and route of attack are determined. Modern air and space forces can improve the ways they incorporate weather prediction into their planning cycle, especially with the advent of new and faster ways to access and visualize relevant, real-time weather information.

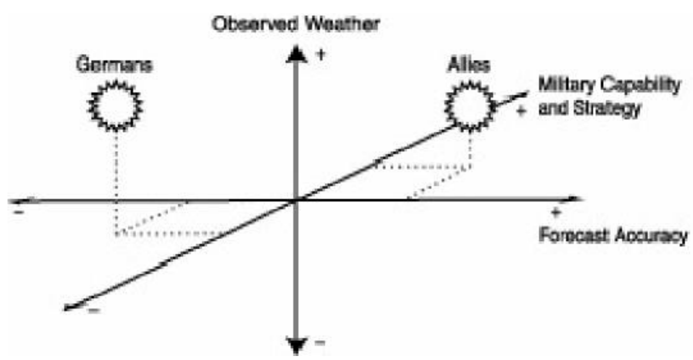
One can depict the three aspects of weather exploitation for both friendly and enemy forces in terms of eight combinations of military capability, observed weather, and forecast accuracy (fig. 2). The ideal goal of weather exploitation is for friendly forces to have superior capability, favorable weather for operations, and accurate forecasts, while simulta-neously forcing the enemy into a situation of inferior capability, unfavorable weather for operations, and inaccurate forecasts. This does *not* translate into attacking enemy targets only in "good" (unobstructed) weather since, presumably, the weather is also favorable for the enemy to defend. But achieving the ideal exploitation situation is



	Forecast Accuracy	Observed Weather	Military Capability
1.	+	+	+
2.	+	−	+
3.	+	+	−
4.	+	−	−
5.	−	+	+
6.	−	−	+
7.	−	+	−
8.	−	−	−

	Forecast Accuracy	Observed Weather	Military Capability and Strategy
+	Good	Favorable for operations	Trained troops, good equipment, strategy
0	Marginal skill	Marginal for operations	Fair training, fair equipment, strategy
−	Poor to no skill	Unfavorable for operations	Poorly trained troops, inadequate or poor equipment, poor strategy

Figure 2. Aspects of Weather Exploitation



	Forecast Accuracy	Observed Weather	Military Capability
Allies	+	+	+
Germans	−	+	−
Exploit by	Allies	Germans*	Allies

*Although the Germans actually had more favorable weather for defensive operations than the Allies did for offensive operations, they could not exploit it because they forecast the weather to be unfavorable for the Allied invasion!

Figure 3. Weather Exploitation during D Day

very difficult. The goal of DOD weather services should be to put friendly forces into situations with favorable weather and accurate forecasts (fig. 2, boxes 1 or 3), while avoiding situations with inaccurate forecasts (boxes 5–8). Unfavorable weather for operations (boxes 2 and 4) may be unavoidable under certain operational circumstances, but at least alternative strategies could be planned and executed, based on accurate foreknowledge of the upcoming weather conditions in-theater.

One should not infer that weather effects and forecast accuracy constitute two-thirds of the problem to be considered by military planners. However, this *is* the correct perspective for the military meteorologist who is knowledgeable about data collection, weather analysis, and forecasting, and is also an expert on the ways in which the natural environment affects military operations in terms of weapon systems, tactics, and combat operations.

One can use the matrix in figure 2 to examine the D-day invasion (fig. 3). Although the Allies had superior military capability and a highly accurate weather forecast for the invasion, the observed weather was *very* marginal for the amphibious landing. Interestingly, the Germans actually had an advantage over the Allies in terms of observed weather, since it was more favorable for defensive than for offensive operations—if they had only known it! The pessimistic forecast made by the Germans caused their forces to stand down, increasing the Allies' advantage along the military capabilities axis (fig. 3).

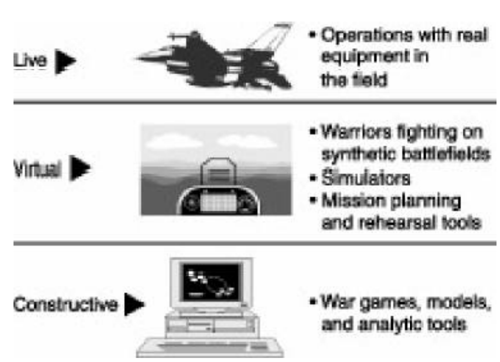


Figure 4. Types of DOD Models and Simulations

Figure 5. Modeling and Simulation Mission-Application Areas

Why Use Modeling and Simulation?

Many of us have heard the familiar arguments (e.g., cost-effectiveness and saving "wear and tear" on equipment and the environment by limiting live-fire testing) used by the services and DOD agencies to advocate M&S. There are three types of models and simulations (fig. 4). Live simulations involve real operators and real equipment (traditional); virtual simulations involve real operators with computer-generated equipment; and constructive simulations involve synthetic equipment and operators.

Another important point about models and simulations is their myriad uses, especially in terms of application to DOD mission areas (fig. 5). Indeed, simulation is becoming more ingrained into the way DOD does business. For example, "computer-generated" forces such as those being developed by the Defense Advanced Research Projects Agency's Synthetic Theater of War program, complete

with doctrinally correct behaviors, will soon be available to develop, test, and evaluate strategies and tactics in ways never before possible. This capability would allow simulation of an amphibious assault using different tactics, force-mix structures, troop-experience levels, and environmental conditions before actually executing it in live training. More importantly, it would also allow mission planning and rehearsal during the critical weeks and days before the actual operation takes place.

Exploiting Weather Using Modeling and Simulation: Our Plan of Attack

Integrating air and space weather and its effects into models and simulations (fig. 6) is based on the modeling-and-simulation pyramid concept, building from the highest level of fidelity (most detailed: system level) to the lowest (most aggregated: campaign level).

Understanding Environmental Effects on Systems

Most atmospheric and space environmental-representation models produce analyses and forecasts of the basic meteorological or space environmental fields (e.g., wind, temperature, moisture, and density) and cannot by themselves produce environmental effects. The basic physics models must be adapted for M&S applications, such as building a weather scenario based on the local climatology of a potential "hot spot" for use in simulation of a sensor that is under development. At this step, we will also build sophisticated environmental-effects models that will be "hooked into" system-level simulations. These simulations will be used to develop a knowledge base about system-component weather sensitivities (e.g., effects of ceiling, visibility, and obscurants on PGM lock-on range; and effects of Van Allen radiation belts on a satellite's shielding capabilities).

Simulating Environmental Effects on Engagements

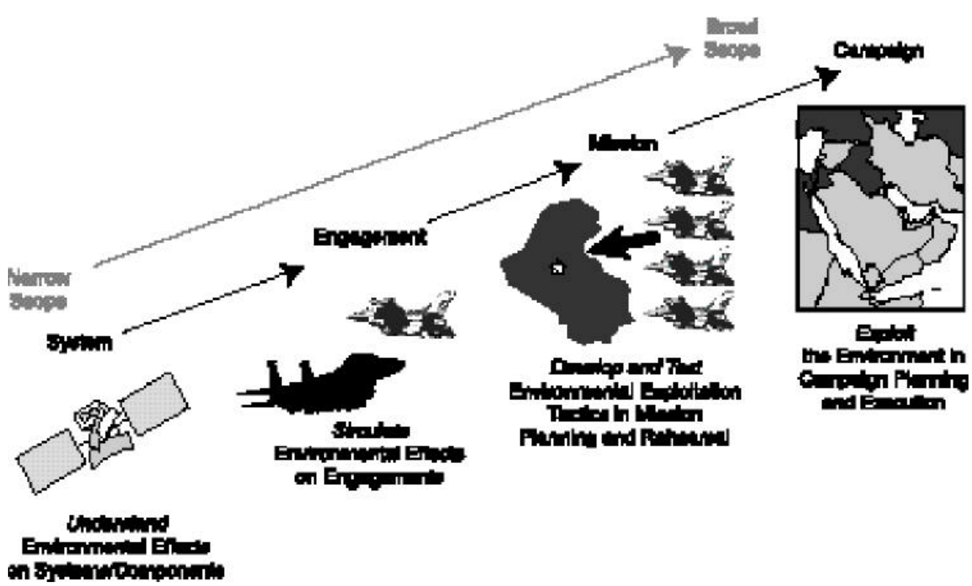


Figure 6. Integrating Weather into Models and Simulations

At this step, we integrate the natural environment into simulations such as the Joint Modeling and Simulation System (JMASS) for simulating the environmental effects on individual engagements (e.g., the effects of ceiling, visibility, and obscurants on PGM lock-on range for an F-22 mission that engages armor). The simulations would be used to understand weather sensitivities in an engagement scenario and develop exploitation strategies. When we know what these exploitable weather situations are, we will direct our research into improving our abilities to observe, analyze, and predict them.

DOD weather services must identify, analyze, and predict weather regimes that are exploitable by US airpower and space power.

Developing and Testing Environmental Exploitation Tactics in Mission Planning and Rehearsal Simulations

When we begin to understand weather's effects on the performance of individual weapons, aircraft, and satellites, we will use this information to simulate environmental effects that can occur when the systems are operating together in-theater, as in a mission rehearsal for a surgical strike. The results of these studies will allow the cumulative results of environmental effects to be aggregated into environmental "impacts" on theater-level operations. These studies will yield valuable information about using weather as a force multiplier to enhance the four-dimensionality of airpower and space power.

Exploiting the Natural Environment in Campaign Planning and Execution

By this stage, many studies of environmental effects on individual systems, one-on-one engagements, and mission planning and rehearsal will have been completed. At this step, we begin building these aggregated environmental impacts into campaign-level models such as the Joint Warfare System (JWARS) and the models of the Joint Simulation System (JSIMS). Here, the synergy between various factors (e.g., ROEs and political factors) can be modeled so that the effects of weather do not operate in isolation from other factors in the simulation. The resulting simulations can be used to address such issues as how our theories of weather exploitation affect the planning and execution of the air campaign.

Applying "Weather Intelligence" during the Early Stages of a Major Regional Contingency

A JFC operating in an austere environment in the early stages of a developing MRC may have limited assets in-theater and a less than fully developed infrastructure. Target selection will be influenced significantly by the theater mission objectives and the actions of the enemy. With limited resources, the JFC wants to adopt a conservative strategy to buy time until more assets arrive in-theater. One of the ways the JFC implements the strategy is by asking the weather staff to take a conservative approach to weather prediction (i.e., to err on the pessimistic side). Previous campaign planning simulations had revealed the effects of such an overall cautious approach to the campaign strategy, using measures of effectiveness such as "missed target opportunities." These same simulations also used real-time weather as inputs into their deployment modules, so weather's effects on the deployment schedule are also known to the JFC staff. These effects are factored in with other considerations, such as movement of enemy armor. Subsequent adjustments are made, based on new mission-planning simulations using this strategy. *Everyone* is involved—the staff weather officer, intel staff, targeteers, logisticians, operators, and so forth.

Conclusions and Recommendations

The above scenario lies well into the future. Making it happen will require considerable "front loading" to build the models and do the studies in order to get the return on investment. Even so, we cannot rely totally on computer models and simulations to get us where we want to go; live operations will be a key component of this strategy. Is exploitation feasible, given the outline presented here? The recent appointment by the undersecretary of defense for acquisition and technology of three M&S executive agents for the natural environment (terrain, oceans, and air and space) is a step in the right direction.[11] These executive agents can provide the necessary leadership to the teams of scientists, analysts, and operators for incorporating the effects of the natural environment into the next generation of models and simulations. None of the above groups alone has the entire picture, but together they can accomplish a great deal. Operators have a special role to play, in that they can provide advocacy and feedback to developers of models and simulations used for training, operations, acquisition, and analysis.

Recently published Air Force executive guidance states the need for US airpower to exploit an adversary's inability to operate in adverse weather, as well as a requirement for incorporating atmospheric effects into models and simulations.[12] Developing proper strategies for exploitation will be a team effort and will require some fundamental changes to weapon-system development policies and our approach to atmospheric research and development. The following recommendations lay the groundwork to begin this pro-cess:

Test and evaluate Air Force systems in as many types of adverse environmental conditions as possible. If US air and space forces are to exploit weather, we must first know what types of weather phenomena are "exploitable." Testing under ideal environmental conditions does not allow measurement and analysis of this sensitivity, and cost and safety considerations limit the amount of adverse-weather testing that can be done on new weapon systems. Therefore, we should use simulations with sophisticated weather-effects representation for much of the adverse-weather testing.

Just as US forces now exploit the night, so will they be able to fight smarter and more efficiently by exploiting the weather—and the resulting savings in human life and materiel will be immeasurable.

Emphasize analysis of weather effects and weather prediction on military operations. There is little quantitative data on the effects of weather and forecast accuracy on military operations.[13] Since any doctrine is based on "tried and true" strategy and tactics tested live in the field, we need much data collection and analysis before we can incorporate weather exploitation into Air Force doctrine. In today's shrinking force, with all its expectations and limitations, the opportunities for collecting necessary data and developing exploitation strategies are extremely limited. The only hope for collecting enough data, as well as developing and testing the resulting strategies and tactics, lies in a combination of live, virtual, and constructive simulations. Once collected and analyzed, this information can be placed in a location such as the M&S Resource Repository, where (with proper security) it can be made accessible for reuse and new applications.

Identify, analyze, and predict weather regimes that are exploitable by US airpower and space power. The best chances for exploiting adverse weather will be in those situations in which US forces have superior tactics, training, and sensor/weapons technology. These "exploitable" situations will likely occur when atmospheric conditions are on the verge of becom-

ing "weather-restricted" and when the atmosphere likely does not fit well-known, conceptual (mental) models of weather systems. Much of today's academic and laboratory research in meteorology focuses on "extreme," nonexploitable events (e.g., "Storm of the Century"—March 1993 US East Coast storm) that conform to well-researched conceptual models of the atmosphere. We advocate funding research efforts aimed at developing capabilities to identify, analyze, and forecast those environmental conditions that are exploitable by US airpower.

With strong advocacy from senior leaders in the Air Force and the Office of the Secretary of Defense and with technical direction from the executive agents, it is possible to build a future air and space doctrine that will speak of exploitation in the vertical, time, and information "dimensions." This effort can serve as a building block for unsurpassed C^2 and information-operations capabilities into the twenty-first century. Just as US forces now exploit the night, so will they be able to fight smarter and more efficiently by exploiting the weather—and the resulting savings in huan life and materiel will be immeasurable. □

Notes

1. Sun Tzu, *The Art of War,* ed. James Clavell (New York: Delacorte Press, 1983), 20. The actual quote is, "If you know Heaven and know Earth, you may make your victory complete." In this context, "Heaven" refers to "night and day, cold and heat, times and seasons," and "Earth" refers to "distances . . . danger and security; open ground and narrow passes; the chances of life and death" (page 7).

2. Bruce Bennett, "Initial Observations on the Future of War," in *JICM 1.0 Summary* (Santa Monica, Calif.: RAND, 1994), 23–27.

3. AFDD 1, "Air Force Basic Doctrine," September 1997, 21–22.

4. The Army, for example, has made a commitment to "owning the weather" as part of its battlefield-support vision for Force XXI. See Mary Ann Seagraves and Richard J. Szymber, "Weather: A Force Multiplier," *Military Review,* November–December 1995, 69–76.

5. See, for example, Gene Myers's remarks in "A Commentary: Interservice Rivalry and Air Force Doctrine: Promise, Not Apology," *Airpower Journal* 10, no. 2 (Summer 1996): 63. He describes one view of airpower as the source of "'immaculate interdiction'—a quick way to punish offenders while not risking many American lives or exposing the resultant blood and destruction to much media scrutiny" (page 63).

6. Lt Col Edward Mann, "One Target, One Bomb: Is the Principle of Mass Dead?" *Airpower Journal* 7, no. 1 (Spring 1993): 36.

7. Comdr Dale R. Hamon and Lt Col Walter G. Green III, "Space and Power Projection," *Military Review* 74, no. 11 (November 1994): 64.

8. AFW 96-01, *Air Force Weather Impact on Operations,* 1996, 2-1.

9. Air Force News Service, "Collateral Damage Edict Challenges Pilots," 8 September 1995.

10. In this context, "relevant" weather is defined as those environmental parameters pertinent to military operations. For example, soil trafficability is pertinent to ground troops, cloud ceilings and line-of-sight visibility are pertinent to tactical air, and frontal positions and vertical motion are pertinent to the forecaster.

11. "Department of Defense Appoints Executive Agents for Modeling and Simulation of the Natural Environment," *Bulletin of the American Meteorological Society,* August 1996, 1890.

12. United States Air Force, *Air Force Executive Guidance* (Washington, D.C.: Department of the Air Force, January 1996), 14–15, 20–21, 25–26.

13. AFW 96-01, 2-2, 2-16, 8-1.